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APPLICATION FOR LETTERS PATENT

REMOTE SYSTEM ADMINISTRATION USING COMMAND LINE ENVIRONMENT

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TECHNICAL FIELD

This invention relates to network system administration, and more particularly, to a command line environment for remote network system administration.

BACKGROUND OF THE INVENTION

Computing systems and networks today are complex and often vast. Some large enterprises may have thousands of individual computing systems interconnected over local and wide area networks. Keeping all these computing systems running smoothly is crucial to the success of an enterprise. For this reason, system developers endeavor to provide useful administrative tools for system administration.

Because the typical system administrator is a very sophisticated user, administrative tools are often more complex than applications intended for the consuming public. For example, command line environments are still popular with system administrators, even though the graphical user interface is preferred by ordinary users. Often, administrators can perform relatively complex tasks quicker using a command line than with a graphical interface.

The typical command line environment is provided by a shell operating on a computing system. Typically, the command line environment provides a few core commands that the administrator can execute. For more complex tasks, typical command line environments allow commands to be "pipelined," which means that two or more commands can be entered on the same command line, and

the results of each command are "piped" or passed to the next command in the pipeline.

Despite their popularity with administrators, there has been little attention paid to making the command line environments more usable and powerful, especially for remote system administration. For instance, frequent is the case when an administrator must perform some action on a remote computer or using information gathered from one or more remote computers. However, even relatively simple tasks prove daunting when remote execution is called for. In addition, the complexities of state of the art computing systems are re-defining what "remote" means. For example, today a "remote" system may be a different process executing on the same computer, yet existing command line environments ignore these situations.

Until now, a command line environment that provides sophisticated remote system administration has eluded those skilled in the art.

SUMMARY OF THE INVENTION

The invention is directed to mechanisms and techniques for sophisticated remote system administration. Briefly stated, a command line environment is configured to receive a command line that implicates a plurality of remote nodes. The command line environment is configured to establish a session, which may be persistent, to each implicated remote node, and to initiate execution of the remote command on those nodes. The session may be assigned to a variable, and the remote execution may be performed concurrently. Results of the remote execution

are received and may be aggregated into an array. The command line environment may distribute the task of establishing sessions to other systems to improve performance.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a functional block diagram generally illustrating a computing environment that benefits from the mechanisms and techniques described in conjunction with the present invention.

Fig. 2 is a functional block diagram illustrating in greater detail the operation of the command line environment introduced in Fig. 1.

Fig. 3 is a functional block diagram of a hierarchical topology of computing systems in a networked environment that may be administered by the command line environment described.

Fig. 4 is a logical flow diagram generally illustrating steps that may be performed by a process for remotely executing at least a portion of a command line instruction.

Fig. 5 is a logical flow diagram generally illustrating a process for enhancing the performance of the command line environment when issuing a remote command to a large number of remote devices.

Fig. 6 is an exemplary computing device that may use an illustrative command line environment.

DETAILED DESCRIPTION

The following detailed description pertains to one illustrative implementation of a command line environment for executing remote commands.

This disclosure is for the purpose of illustration only, and is not to be viewed as the only method of implementing the invention.

Fig. 1 is a functional block diagram generally illustrating a computing environment **100** that benefits from the mechanisms and techniques described in conjunction with the present invention. Illustrated are several computing systems connected over a network **110**. More particularly, the network **110** connects an "administrator" **112** computing system to several remote computing systems (e.g., Remote A **120**, Remote B **121**, and Remote C **122**. The several computing systems may be parts of an enterprise network or any other administered network environment. The remote computing systems may be physically located anywhere.

The network **110** may be any mechanism for connecting different computing systems, such as a local area network, a wide area network, or the Internet. Each of the remote computing systems may be an individual computing system in use by an end user, such as an employee or subscriber.

The administrator **112** is a computing system used by a system administrator or the like to maintain the computing environment **100**. In other words, the administrator **112** runs commands and performs tasks that may query the status or state of other computing systems in the computing environment, and make changes to one or more of the other computing systems. The administrator **112** may also query or alter the state of the network **110**. The administrator **112** includes an execution environment that supports one or more processes, such as

Process A **113** and Process B **114**. Each process hosts at least one program or application. In addition, one process (e.g., Process A **113**) may host one or more application domains, such as App1 **115** and App2 **116**. Application domains are a relatively new mechanism that allows multiple applications to execute within the same process, yet still be isolated from other applications. The application domain is a logical and physical boundary created around an application by a runtime environment. Each application domain prevents the configuration, security, or stability of its respective application from affecting other applications in other application domains.

Each computing system in the computing environment **100** supports a command line environment that implements the mechanisms and techniques described here. As described in greater detail below in conjunction with Fig. 2, the administrator **112** includes a command line environment that allows a user to execute commands both locally and remotely. The administrator **112** is configured to establish a session between its local command line environment (also referred to as the "shell") and any one or more of remote systems. In this implementation, the remote systems include remote computing devices (e.g., remote A **120**), as well as other processes or application domains on the local computing system (i.e., the administrator **112**). Accordingly, unlike existing systems, a user of the administrator **112** may establish a connection and remotely execute commands either on remote computing devices or in another process or application domain on the local computing device. In addition, the administrator **112** creates separate sessions to each remote system and so may initiate a

command for simultaneous execution on multiple remote systems, which has not been done before now.

Fig. 2 is a functional block diagram illustrating in greater detail the operation of the command line environment **200** introduced in Fig. 1. Illustrated in Fig. 2 are the administrator **112** and several remote systems **201**. In this example, two of the remote systems (i.e., Remote A **120** and Remote B **121**) are remote computing devices. In contrast, another remote system (i.e., Remote N **220**) may be another process on the local computer, executing code in another application domain, or the like. In this implementation, the administrator **112** performs remote administration on the remote systems **201**.

Each remote system includes several "commands" (e.g., cmds **222**). The commands are relatively small code components that are used to perform system administrative tasks. Examples may include a "process" command for identifying each process executing on a computing device, a "dir" command for identifying the files in a directory on a computing device, and many others. However, the commands may include any executable component on a remote system.

Each of the remote systems **201** also includes a remote agent (eg., Agent **224**), which is a component that responds to remote requests to execute one or more commands (e.g., cmds **222**). In addition, the agents are configured to take the results of the execution of one or more commands and create a package that is returned to the requesting device. In one implementation, the package takes the form of a serialized object that includes the results of execution, as well as meta

information such as the date and time of invocation, identifying information about the particular remote system form which the results originated, and information about the requesting entity. This and perhaps other information is bound up into a return package **226** for transmission back to the requesting entity (e.g., the administrator **112**).

The administrator **112** includes components that support the command line environment **200**. More specifically, the administrator **112** includes commands **250** similar to the commands resident on the remote systems, that are used in system administration. The operations of the command line environment **200** are governed by a core engine **251** that is configured to manage the flow of operation and information among each of the several components, and between the administrator **112** and each remote system **201**. The core engine enables user input to be received (such as through a shell or the like) in the form of command line instructions, and acted upon. The particular format of such a command line instruction and the techniques for handling one are described in greater detail below.

Additionally, the command line environment **200** includes a session manager **253** function. The command line environment **200** is configured to execute remote commands on multiple remote systems concurrently. To achieve this, a different "session" is established between the administrator **112** and any remote systems **201** identified in a command line instruction. The "session" **230** represents a connection between the administrator **112** and the associated remote systems **201**. In response to a command line instruction that implicates a remote

system, the session manager **253** interacts with the agent (e.g., Agent **224**) on the remote system to invoke a process on the remote system and to create a connection to that process. That connection is termed a "session." One or more sessions may be established from the command line using a particular command, such as may take the following form:

```
$C = new/session -node N1,N2,N3 -creds {XXX} -session yes
```

In this example, the phrase "new/session" indicates that a new session is to be created. The parameter "-node N1,N2,N3" indicates the nodes (remote systems) to which the session(s) are being created. As an alternative to the "-node" parameter, a "–workerprocess" parameter may be used to create a session to an alternate process on the local machine, or a "-appdomain" parameter may be used to create a session to another application in a different application domain in the same process. The parameter "-creds {XXX}" identifies any particular logon credentials used to connect to the remote system **201**. And finally, the parameter "-session yes" is used to indicate whether to persist the session or not. Persisting a session is useful in the case where multiple commands may be called remotely using different command lines. Unlike prior systems, a session allows a remote process to be reused for multiple command line instructions. This ability improves automated administration and scripting.

Referring again to the example command line above, the use of the "$C = " syntax in conjunction with creating the new session assigns the new session to the environment variable "$C." Environment variables **275** are essentially variables

maintained by the shell that are made available to other tasks and are often used to share information between processes or applications. By assigning a session to an environment variable, different commands can make use of the session by simply referring to the environment variable. Also, since a single session can include connections to multiple remote systems, several commands can be issued by issuing them to a single environment variable, thus greatly simplifying larger scale ("1:many") administrative tasks. What follows here is an illustrative command line that may be used to take advantage of this capability:

```
$A = rcmd $C get/process
```

This example builds on the prior example by invoking the remote command (rcmd) get/process on the remote systems having sessions identified in the environment variable "$C". In accordance with the above command line, each remote command is initiated simultaneously. This feature is a great enhancement over existing command line environments, which would have required the coding of a loop or similar operation to launch the command on each remote system. In this way, the technique of this implementation achieves the performance benefit of concurrent command processing, rather than having to serially execute each remote command.

In addition, the results of each of the individual remote commands are aggregated into the environment variable "$A" by an aggregator **255**. In other words, when one remote system having a connection referenced in the session "$C" returns its return package (e.g., return package **226**), the aggregator **255**

includes that data in the specified environment variable, "$A" in this instance. In this way, subsequent commands and tasks have access to the results of performing the command on multiple remote systems. The results are stored in the environment variable as an aggregated array. The aggregator **255** stores information that associates the origin of each results package with its particular index in the environment variable. In this way, components of the command line environment **200** have ready access to the results on a per-machine, per-process, or per-application domain basis if needed or desired. In one implementation, the aggregated results are made available in a synchronous fashion, e.g. when all the results are returned. Alternatively, the results may be made available through the environment variable as they are received.

In a similar vein, the core engine **251** may cause a command line to be executed in a disaggregated way, such that a command can have access to the results of a remote execution as the results are returned. For example, if a user were interested in locating any one of multiple remote computing devices that had in excess of a certain amount of free storage, then the execution of the command could terminate appropriately once the first such device were located. In this case, the aggregator **255** and the core engine **251** may interact so that the results are evaluated asynchronously. In this case, the origin information for the results is still made available.

The case can be envisioned where a command is intended for execution on very many remote devices, such as perhaps hundreds or even thousands. In that case, it may be preferable not to simultaneously launch all the commands at once.

If so, a "throttler" function **257** may be used for performance enhancement. The throttler **257** interacts with the core engine **251** and perhaps the session manager **253** to limit the number of connections that are made in a session so that the network or the resources of the administrator **112** are not overly burdened. For example, a "-throttle 50" parameter may be used on the command line to indicate that no more than 50 connections should be active at any one time. This enhancement helps to prevent overburdening the resources of the administrator **112** or the network. Alternatively, the throttler **257** could also interact with other performance-based mechanisms to regulate the performance impact of a remote command execution. For instance, the throttler **257** may interact with a QOS (Quality Of Service) mechanism to limit the impact on network bandwidth. In addition, the throttler **257** could be configured to interact with each remote agent to regulate the performance impact on each remote system, such as processor or memory load, or the like.

Fig. 3 is a functional block diagram of a hierarchical topology **300** of computing systems in a networked environment that may be administered by the command line environment just described. It can be envisioned that the system described above may be used to issue remote instructions to very many remote devices, such as in a large enterprise network. Accordingly, the command line system implements the hierarchical topology **300** to avoid overburdening the administrator **112** when a large number of connections are being made.

As illustrated, the topology **300** includes the administrator **112** and a distributed network **301** of computing devices. The distributed network **301**

includes a hierarchical layout with a first level **310** of computing devices composed of servers (i.e., Server A **302**, Server B **303**, and Server C **304**) that each control a group of child computing devices at a second level **312**. One or more of the computing devices at the second level (e.g., Server D **361**) may in turn have its own children at a third level **314**, and so on. The distributed network **301** shown in Fig. 3 is illustrative only, and it will be appreciated that complex enterprise networks can have multiple layers of servers and thousands of computing devices.

In this implementation, several of the computing devices in the distributed network **301** include components (e.g., Agent **308**) that may interact with the administrator **112** in a cooperative way to help distribute the performance of a command instruction. More specifically, a command line instruction issued at the administrator **112** may affect a very large number of the computing devices in the distributed network **301**. Accordingly, the administrator **112**, rather than locally initiate all the connections necessary to perform the instruction, distributes the task among several children in the distributed network **301**. This distribution may be performed in at least two ways.

First, in the case where the administrator **112** does not have knowledge of the layout of the distributed network **301**, the administrator **112** may issue the command instruction to each server in the first level **310** with further instructions to cause the command to be executed on each of their children or any of their children that are in an identified set of affected nodes. In that way, the task of actually launching each connection is distributed to other computing devices. The

computing devices in the first level **310** may additionally delegate some of the execution to subordinate computing devices in the second level **312**, such as Server D **361**.

Second, in the case where the administrator **112** has knowledge of the layout of the distributed network **301** and can identify which leaf nodes are controlled by which servers, the administrator **122** may decompose the command into subcommands for each branch in the distributed network **301** having affected nodes. Then the administrator **112** issues those subcommands directly to the controller for the affected nodes. In essence, this technique allows the administrator **112** to retain governance over which server or node in the distributed network **301** performs the actual execution of the command instruction. Additionally, this technique simplifies the task to be performed by the subordinate computing devices in that they do not need to discover whether they have affected children.

It should be noted that each of these techniques is simplified because the return results (see Fig. 2) include sufficient information to identify the origin of the results and the command instruction to which the results pertain. In the absence of this information, the administrator **112** and each delegate would need to coordinate to ensure that the returned results could be attributed to a particular node, if that information were required.

Fig 4. is a logical flow diagram generally illustrating steps that may be performed by a process **400** for remotely executing at least a portion of a

command line instruction. The process **400** begins at step **401**, where a command line is received by a command line execution environment. Although any command line execution environment suitable for implementing the described techniques is acceptable, the command line environment described in co-pending U.S. Patent Application Number 10/693,785, entitled Administrative Tool Environment, filed on October 24, 2003, is especially well suited. That U.S. Patent Application is expressly incorporated herein by reference in its entirety.

At step **403**, it is determined that the received command line includes at least one command to be executed remotely on one or more remote systems. Remote execution includes execution on either a remote computing device, another process on the local computing device, or a task in another application domain within the same local process.

At steps **405** and **407**, the command line environment causes a persistent session to be initiated to each identified remote system, and causes each remote system to execute the remote command. Alternatively, a single session may be used that includes separate connections to each remote device. As mentioned above, the persistent session may be assigned to an environment variable. In addition, each connection in the session may be serially or concurrently caused to execute the remote command. A performance enhancement to these steps is illustrated in Fig. 5 and described below.

At step **409**, the results of the remote execution of the commands is received. As mentioned, the results make be in the form of a return package or

serialized object that includes the results of the execution as well as other identifying information about which remote node executed the command and the like.

Fig. 5 is a logical flow diagram generally illustrating a process **500** for enhancing the performance of the command line environment when issuing a remote command to a large number of remote devices. The process **500** begins at step 51, where the command line is decomposed into a number of subcommands based on which affected nodes are governed by which controller in a set of controllers. Then, at step **503**, each subcommand is issued to each identified controller for that particular controllers affected nodes. Finally, at step **505**, the results that are returned from each controller are aggregated. Because each of the results includes information about the originating node, the aggregation step does not lose valuable information about which node generated the results, if that information is necessary.

The command line environment described above has several advantages over existing systems. The ability to persist a session allows a remote process to be reused for multiple commands. Multiple connections may be aggregated into a session, allowing simple concurrent processing of a remote command without resort to worker threads or the like. And the task of executing the remote command may be distributed to other systems to enhance performance. These and other advantages will become apparent to those skilled in the art.

Fig. 6 illustrates an exemplary computing device that may be used in an exemplary command line environment. In a very basic configuration, computing device **600** typically includes at least one processing unit **602** and system memory **604**. Depending on the exact configuration and type of computing device, system memory **604** may be volatile (such as RAM), non-volatile (such as ROM, flash memory, etc.) or some combination of the two. System memory **604** typically includes an operating system **605**, one or more program modules **606**, and may include program data **607**. The operating system **606** include a component-based framework **620** that supports components (including properties and events), objects, inheritance, polymorphism, reflection, and provides an object-oriented component-based application programming interface (API), such as that of the .NET™ Framework manufactured by Microsoft Corporation, Redmond, WA. The operating system **605** may also include a command line environment **200**, such as that described above. This basic configuration is illustrated in Fig. 6 by those components within dashed line **608**.

Computing device **600** may have additional features or functionality. For example, computing device **600** may also include additional data storage devices (removable and/or non-removable) such as, for example, magnetic disks, optical disks, or tape. Such additional storage is illustrated in Fig. 6 by removable storage **609** and non-removable storage **610**. Computer storage media may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, program modules, or other data. System memory **604**, removable storage **609** and non-removable storage **610** are all examples of

computer storage media. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by computing device **600**. Any such computer storage media may be part of device **600**. Computing device **600** may also have input device(s) **612** such as keyboard, mouse, pen, voice input device, touch input device, etc. Output device(s) **614** such as a display, speakers, printer, etc. may also be included. These devices are well know in the art and need not be discussed at length here.

Computing device **600** may also contain communication connections **616** that allow the device to communicate with other computing devices **618**, such as over a network. Communication connections **616** are one example of communication media. Communication media may typically be embodied by computer readable instructions, data structures, program modules, or other data in a modulated data signal, such as a carrier wave or other transport mechanism, and includes any information delivery media. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media. The term computer readable media as used herein includes both storage media and communication media.

Although details of specific implementations and embodiments are described above, such details are intended to satisfy statutory disclosure obligations rather than to limit the scope of the following claims. Thus, the invention as defined by the claims is not limited to the specific features described above. Rather, the invention is claimed in any of its forms or modifications that fall within the proper scope of the appended claims, appropriately interpreted in accordance with the doctrine of equivalents.